NASA TECHNICAL MEMORANDUM

NASA TM X-64976

(NASA-TM-X-64976) EVALUATION OF ULTRASONICS AND OPTIMIZED RADIOGRAPHY FOR 2219-T87 ALUMINUM WELDMENTS (NASA) 27 p HC $4.00 CSCL 13H
N76-16445
Unclas
G3/37 10000

EVALUATION OF ULTRASONICS AND OPTIMIZED RADIOGRAPHY FOR 2219-T87 ALUMINUM WELDMENTS

By W. N. Clotfelter, J. M. Hoop, and P. C. Duren
Materials and Processes Laboratory

November 15, 1975

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. NASA TM X-64976	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Evaluation of Ultrasonics and Optimized Radiography for 2219-T87 Aluminum Weldments		5. REPORT DATE November 15, 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) W.N. Clotfelter, J.M. Hoop, and P.C. Duren		8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. 13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D.C. 20546		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES Prepared by Materials and Processes Laboratory, Science and Engineering		

16. ABSTRACT

Quantitative flaw size data are necessary to make reliable decisions on weld acceptability. Nondestructive inspections are usually qualitative in nature and less effective in measuring defect size. The ultrasonic studies described in this report are specifically directed toward the quantitative measurement of randomly located defects previously found in aluminum welds with radiography or with dye penetrants. Experimental radiographic studies were also made to optimize techniques for welds of the thickness range to be used in fabricating the External Tank of the Space Shuttle.

Conventional and innovative ultrasonic techniques were applied to the flaw size measurement problem. Advantages and disadvantages of each method are discussed. Flaw size data obtained ultrasonically are compared to radiographic data and to real flaw sizes determined by destructive measurements. Considerable success was achieved with pulse echo techniques and with "pitch and catch" techniques.

The radiographic work described in this report demonstrates that careful selection of film exposure parameters for a particular application must be made to obtain optimized flaw detectability. Thus, film exposure techniques can be improved even though radiography is an old weld inspection method.

17. KEY WORDS		18. DISTRIBUTION STATEMENT W. N. Clotfelter Unclassified — Unlimited	
19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 26	22. PRICE NTIS

MSFC - Form 3292 (Rev December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22151

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

TECHNICAL MEMORANDUM X-64976

EVALUATION OF ULTRASONICS AND OPTIMIZED RADIOGRAPHY FOR 2219-T87 ALUMINUM WELDMENTS

SUMMARY

Radiography and dye penetrants are to be used in nondestructively evaluating welds of the Space Shuttle External Tank. Both methods are useful for detecting and indicating the length of defects, but they are not suitable for flaw depth measurements. However, flaw depth and length data are necessary to make reliable decisions on weld acceptability. Consequently, any defects located by radiography or with penetrants must be carefully measured by utilizing some other method to obtain flaw size data. An ultrasonic pulse echo technique was used to measure the length of weld defects and an ultrasonic "pitch and catch" shadow technique was developed for making accurate crack depth measurements. Flaw size data so obtained compared favorably with real flaw sizes determined by destructive measurements.

Weld bead conditions affect the accuracy of both ultrasonic techniques, but reliable measurements can be made if bead profiles are low and uniform. However, as demonstrated with a 10 MHz pulse echo, back-reflection technique, accuracy and repeatability can be improved by removing all excess weld bead material. The high quality ultrasonic measurements obtainable under these conditions demonstrate that radiography could be eliminated from the weld evaluation process.

Radiographic work described in this report demonstrates that a careful selection of film exposure parameters for a particular application must be made to obtain optimized flaw detectability. Lower voltages and longer exposure times than those ordinarily used for aluminum welds yield improved results. Low and uniform weld bead profiles also enhance radiographic detection. However, radiography and state-of-the-art ultrasonics complement each other, and the combination provides good flaw detection capability even when the weld bead profile is less than optimum.

INTRODUCTION

Initially, all welds in the Space Shuttle External Tank will be inspected radiographically and with dye penetrants. As manufacturing experience is obtained and probable flaw distribution patterns emerge, the percentage of welds to be radiographically inspected will be reduced. Quantitative crack size data are necessary to make reliable decisions on weld acceptability. This is especially true when fracture mechanics technology is used as a guide for weld acceptability. Consequently, any defects located by radiography or with penetrants must be reevaluated and carefully measured to obtain size data. Previous work has demonstrated that ultrasonics has high potential for this application. Therefore, a major objective of the work described in this report was to demonstrate the utility and reliability of ultrasonics as a means of assessing the defect content of aluminum weldments. Since this work is directed toward the measurement of randomly located defects found by other inspection methods, portable ultrasonic instrumentation was selected and manual techniques were developed. A second objective was to optimize basic radiography for nondestructively evaluating 2219 aluminum weldments of a specific thickness range.

The first objective was accomplished by developing specialized ultrasonic techniques and utilizing them to nondestructively evaluate weldment flaws. Subsequently, the specimens were radiographed and destructively evaluated. A correlation of all test results demonstrated the current utility and the future potential of ultrasonics as a weldment evaluation tool. The second objective was realized by relating the longest apparent crack length measured in radiographs obtained using a range of film exposure parameters for each weld specimen. The particular combination of exposure parameters that produced the radiograph having the longest apparent crack length was considered best.

ULTRASONIC FLAW MEASUREMENT TECHNIQUES

Pulse Echo

A Krautkramer Model USK-5 miniature flaw detector and a MWB 70° shear wave angle beam ultrasonic transducer were used for this application. As previously stated, this work is directed toward the manual measurement of randomly located flaws previously found with radiography or dye penetrants, so

portability is important. The 70° shear wave transducer was selected since smaller angles result in greater weld bead reflections and larger angles increase difficulties with surface effects. A commercially available couplant, Exosen 7, sold by Aerotech, Inc. was used because it proved to be superior to oils, greases, and other couplants evaluated with respect to consistency of coupling and energy transfer. Transducer location and orientation with respect to welds being evaluated are illustrated in Figure 1.

The ultrasonic instrumentation was calibrated with the aid of a 1 mm "side drilled hole" of an IIT-IIW calibration block. As illustrated in Figure 2, this is simply a round hole drilled perpendicular to the sound beam path. This type of reference is easily manufactured, is reproducible, and reflections from the hole approximate reflections from typical weld defects more closely than those from a flat bottom hole. Figure 2 illustrates the alignment of the MWB 70° transducer used to maximize the echo from the hole. The calibration block must be made of the same material as the item to be tested, and the same couplant as that to be used in the actual test must be used for calibration.

Test panels were prepared by butt welding 2219-T87 aluminum in 0.32 cm (0.125 in.) and 0.64 cm (0.250 in.) thicknesses using the tungsten inert gas welding process. The panels were intentionally prepared defective by using contaminants. These panels were radiographically and ultrasonically evaluated at 4 MHz with a contact transducer. Subsequently, they were destructively evaluated by sawing them into 4 in. lengths and breaking them with a tensile machine. The actual defects were then measured under a microscope. These data, presented in Tables 1 and 2, were compared to radiographic and ultrasonic data previously obtained.

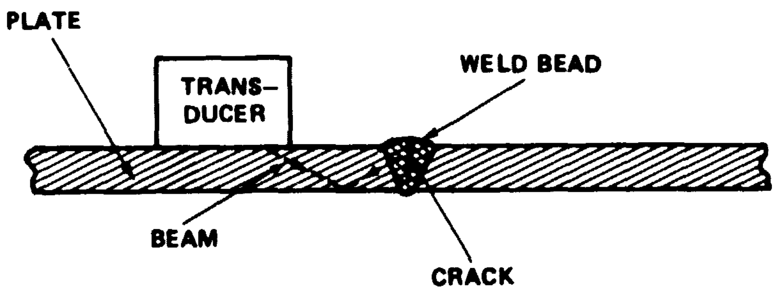

Figure 1. Shear wave crack measurement technique.

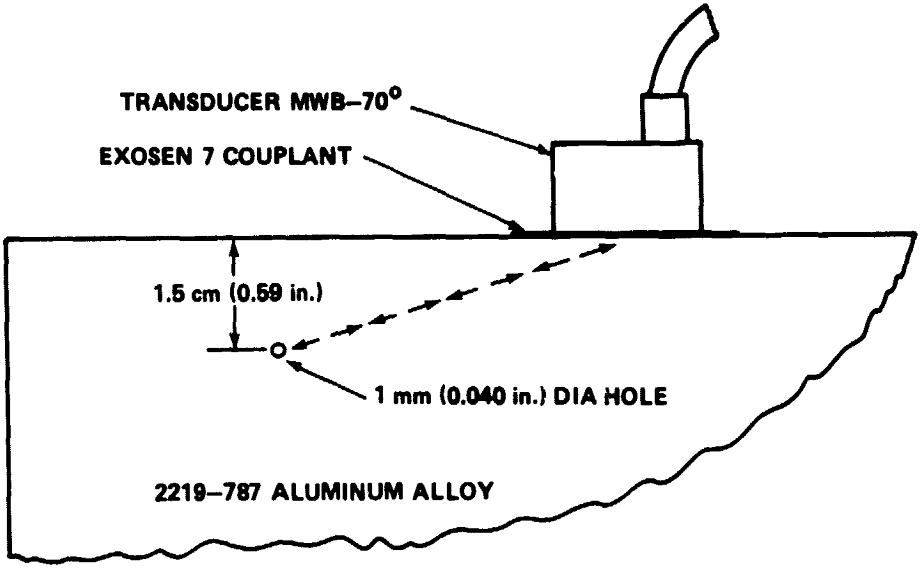

Figure 2. IIT-IIW test block and method of calibration.

Of the observed defects, 74 percent were detected radiographically and 81 percent were detected ultrasonically. All defects not detected ultrasonically and 71 percent of those not detected radiographically were an unusual type of porosity. This undetected "porosity" was rather flat and filled with foreign matter that contained very small voids. The difficulty in detecting this condition is well understood. Ultrasonics will not sense an inclusion unless there is a separation between it and the principal material or unless there is a significant difference between the acoustic impedance of the two materials. Furthermore, X-radiation will not sense an inclusion having a density near that of the principal material. However, as previously stated, these weldments were purposely made defective by applying contaminants to the unwelded aluminum plates, so this particular type of porosity is not likely to occur in flight hardware. The results do depict the basic physics and limitations of both inspection methods. Other defects missed by radiography were insufficient fusion, which was oriented at such an angle with respect to the incident X-radiation as to preclude detection.

It should be emphasized that weld beads of all the specimens discussed in the preceding were unshaved. This unshaved condition constitutes a major limitation to the effectiveness of any nondestructive evaluation method. This is especially true for an ultrasonic method which, with the limitation, consistently

TABLE 1. COMPARISON OF NONDESTRUCTIVE AND DESTRUCTIVE MEASUREMENTS OF WELD DEFECTS FOR SPECIMEN 1

No.	Type	Actual Size, cm (in.)	Indicated Size, cm (in.)	
			Radiographic	Ultrasonic
1	Por. & Incl.	0.46 (0.18)	0.51 (0.20)	0.76 (0.30)
2	Porosity	0.18 (0.07)	0.08 (0.03)	0.25 (0.10)
3	IP & Por.	2.31 (0.91)	2.54 (1.00)	2.54 (1.00)
4	Por. & Incl.	0.25 (0.10)	0.21 (0.08)	0.25 (0.10)
5	Porosity	0.13 (0.05)	0.13 (0.05)	0.25 (0.10)
6	Por. & Incl.	0.41 (0.16)	0.30 (0.12)	0.25 (0.10)
7	Porosity	0.36 (0.14)	0.21 (0.08)	0.25 (0.10)
8	IP & Por.	1.93 (0.76)	0.56, 1.27 (0.22, 0.50)	1.27 (0.50)
9	IP & Por.	2.00 (0.79)	0.33, 0.76 (0.13, 0.30)	0.25, 0.76 (0.10, 0.30)
10	IF & Por.	0.84 (0.33)	0.76 (0.30)	0.76 (0.30)
11	IF & Por.	0.56 (0.22)	0.25 (0.10)	0.25 (0.10)
12	IF & Por.	6.10 (2.39)	3.68, 0.25 (1.45, 0.1)	3.80, 0.25 (1.50, 0.1)
13	IF	1.10 (0.42)	ND	Assumed to be bead
14	IF	2.58 (1.02)	ND	indications

Notes: Por. & Incl. — Porosity and Inclusion
IP — Insufficient Penetration
IF — Insufficient Fusion
ND — Not Detected

TABLE 2. COMPARISON OF NONDESTRUCTIVE AND DESTRUCTIVE MEASUREMENTS OF WELD DEFECTS FOR SPECIMEN 2

No.	Type	Actual Size, cm (in.)	Indicated Size, cm (in.)	
			Radiographic	Ultrasonic
1	Porosity	0.41 (0.16)	ND	ND
2	Porosity	0.23 (0.09)	ND	ND
3	IF & Por.	0.79 (0.31)	0.76 (0.30)	0.51 (0.20)
4	IF & Por.	0.71 (0.28)	0.51 (0.20)	1.02 (0.40)
5	Porosity	0.18 (0.07)	0.30 (0.12)	0.25 (0.10)
6	Porosity	0.15 (0.06)	ND	ND
7	Por. & Incl.	0.48 (0.19)	0.46 (0.18)	2.04 (0.80)
8	IF & Por.	0.79 (0.31)	0.76 (0.30)	1.78 (0.70)
9	IF & Por.	0.71 (0.28)	0.76 (0.30)	0.76 (0.30)
10	IF & Por.	0.56 (0.22)	0.51 (0.20)	0.25 (0.10)
11	IF & Por.	0.53 (0.21)	0.76 (0.30)	0.25 (0.10)
12	Porosity	0.05 (0.02)	ND	ND
13	Porosity	0.23 (0.09)	ND	ND

Notes: Por. & Incl. — Porosity and Inclusion
IP — Insufficient Penetration
IF — Insufficient Fusion
ND — Not Detected

detects a higher percentage of defects in welds than any other method. Shaving weld beads obviously would improve the detectability of porosity filled with foreign matter as well as other types of defects. For example, Figure 3 shows what can be accomplished by shaving weld beads. A 10 MHz pulse echo, back-reflection technique was used to obtain a mirror image of imperfections shown in a radiograph. Obviously the radiograph was made before the bead was shaved. This improved capability, along with the inherent capability of ultrasonics to detect cracks and crack-like defects, provides a very effective tool for the nondestructive evaluation of weldments.

Pitch and Catch

Cracks transverse to weld beads are not as readily detected by the angle beam, pulse echo technique, illustrated in Figure 1, as cracks aligned in the perpendicular direction or at some intermediate angle to the ultrasonic beam. The technique depicted in Figure 4 is more sensitive to transverse cracks and results in a higher signal-to-noise ratio than pulse echo testing. In this pitch and catch technique, the transmitting transducer "T" directs an ultrasonic beam at an angle to the crack from which it is reflected to the receiving transducer "R". The path of the beam through the plate depends on the plate thickness. If the thickness is comparable to the beam size, the plate will be essentially filled with sound and a crack can be detected on either side of the plate. This was found to be true of 0.64 cm (0.250 in.) thick aluminum using the miniature Krautkramer transducers.

An attempt to apply this technique by holding a transducer in each hand was cumbersome and tedious. A fixture was needed to hold the transducers in a selected angular alignment and to provide a certain freedom of motion to allow the transducers to seat themselves on a test specimen. Such a fixture was designed and fabricated. Its major features are illustrated in Figure 5. The transducers are held by flanges that are free to rotate about the points of full dog set screws. These are mounted in brackets that are free to rotate about the ends of a threaded bolt that is bent 90°. In addition to accomplishing other objectives, the bend in the bolt serves as an indicator of crack location. Any cracks detected will be just beyond and at the center of the bend.

A limited amount of testing has been accomplished with the transverse crack detection technique by utilizing the special fixture described. Initial results were encouraging since transverse cracks and inclusions were detected. However, additional work is required to determine the utility and reliability of the technique as a tool for detecting and assessing cracks not located by conventional ultrasonic techniques.

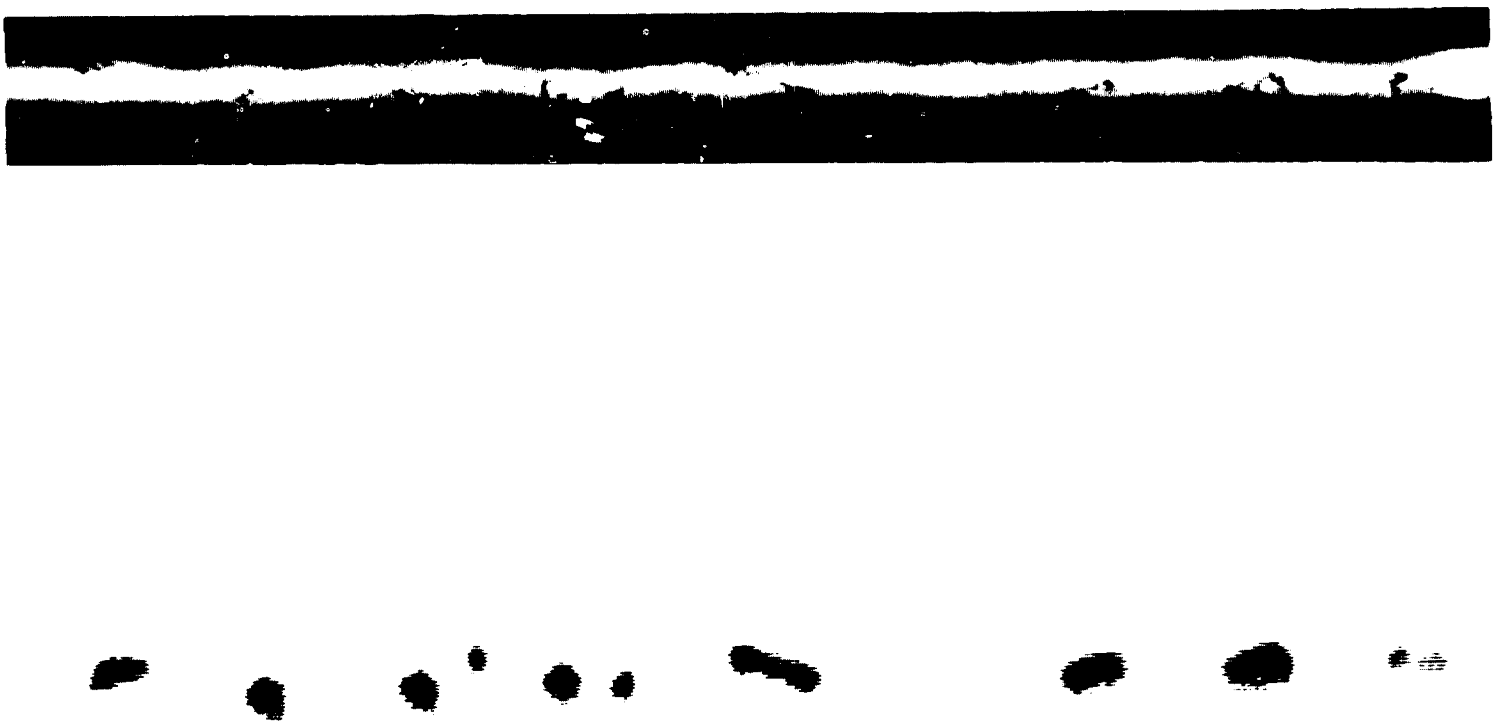

Figure 3. An ultrasonic C-scan of a weld compared to a radiograph of the weld.

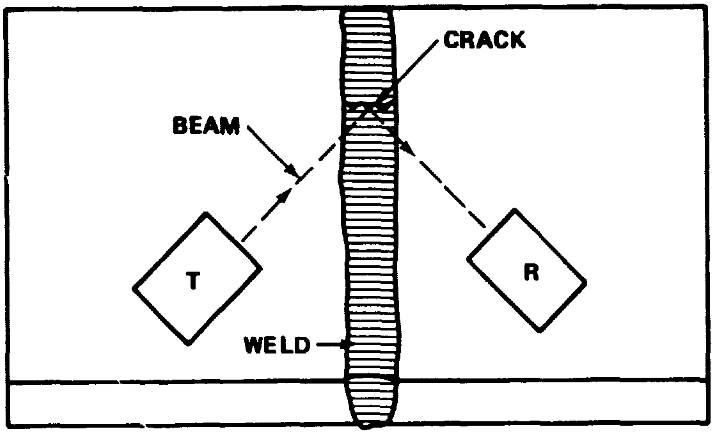

Figure 4. Transverse crack detection technique.

MEASUREMENT OF CRACK DEPTH

Ultrasonic techniques for measuring the depth of cracks in weldments of thin, 0.317 to 1.27 cm (0.125 to 0.5 in.), material are in the experimental stage. Prior to the current project, a pitch and catch shadowing technique utilizing the immersion mode of ultrasonic testing was demonstrated. It worked well but is not suitable for the manual evaluation of randomly located cracks. A recently developed manual technique suitable for this application is depicted in Figure 6. Commercially available miniature transducers are used with a point contact plastic shoe bonded to the receiver. A 45° shear wave technique was selected, since it results in depth and surface shadow measurements being equal. The transmitting transducer "T" reflects a beam from the bottom surface in such a way as to center the tip of the crack in the beam. The receiving transducer "R" is used to locate the edge of the shadow. It is not a sharp point but is located by moving to essentially zero signal, to a plateau, and then to a half-amplitude point. A certain amount of skill is required to locate the end of a crack and the edge of the crack shadow. Crack depth is approximately equal to the distance from the tip of the receiving transducer to the point where the crack reaches the surface. The weld beads were comparatively smooth, and surprisingly reliable signals were received when the point contact transducer was placed on top of them to measure the depth of shallow cracks. Subsequent to the initial depth measurements, the beads were milled off and a second set of

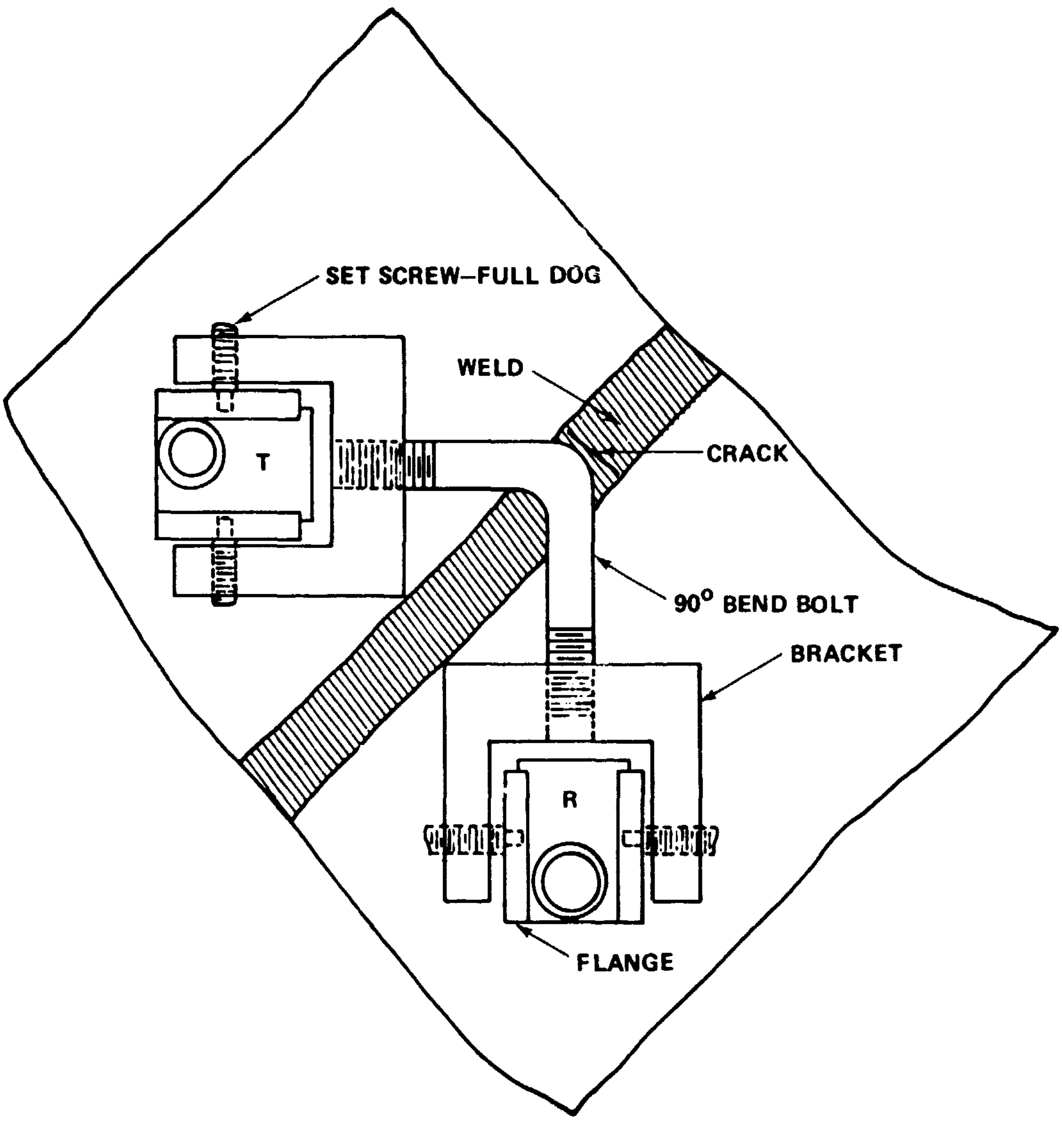

Figure 5. Transducer alignment fixture for use in detecting transverse cracks.

measurements was made. Then, the material was cut into 0.64 cm (0.25 in.) wide metallographic specimens, polished, and etched to reveal crack cross sections. Actual crack depths were measured with a microscope having a calibrated eyepiece reticle. Results of all measurements, nondestructive and

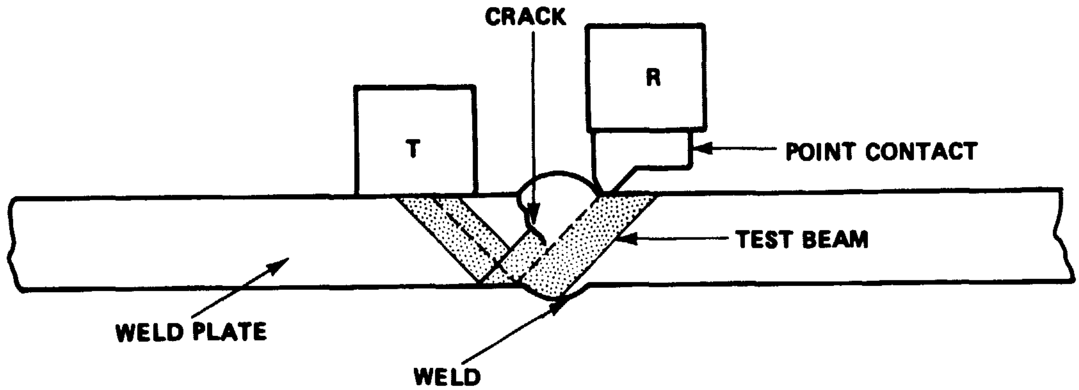

Figure 6. Manual ultrasonic technique for measuring crack depth.

destructive, are presented in Table 3. The "Position" column identifies incremental measurements of metallographic specimens with respect to the center of the aluminum plate. Actual crack depth is compared to the values obtained nondestructively.

In general, the correlation is good for the shaved as well as for the unshaved weld beads. In both cases an accuracy of approximately ±0.10 cm (40 mils) was obtained. Since the cracks were not vertical, this is considered good.

METHOD OF OPTIMIZING RADIOGRAPHIC PARAMETERS FOR WELD EVALUATION

An experienced radiographer knows the approximate values of voltage, amperage, film-source distance, and exposure time for each thickness of aluminum in the 0.317 to 1.27 cm (0.125 to 0.5 in.) thickness range. It is also known that longer exposure times and smaller focal spot sizes will improve film image quality. Usually exposure times for aluminum welds have been held to 1 min or less, and the required 2 percent penetrameter sensitivity is met. However, a reasonable increase in exposure time would be a small price to pay for improved film image quality when critical welds are being evaluated. Thus, effects of exposure time and other radiographic parameters on film image quality have been evaluated so that optimum inspection techniques can be established for each specific material thickness of interest.

TABLE 3. MANUAL ULTRASONIC CRACK DEPTH MEASUREMENTS

Specimen: 2219-T87 weld panel of 1.27 cm (0.5 in.) thickness with stress crack in fusion line.

Position		Depth, cm (in.)		
			Measured	
		Actual	With Beads	Shaved
Left	12	0	0	0
	11	0	0	0
	10	0	0	0
	9	0	0	0
	8	0.51 (0.20)	0.43 (0.17)	0.23 (0.09)
	7	0.56 (0.22)	0.58 (0.23)	0.48 (0.19)
	6	0.66 (0.26)	0.79 (0.31)	0.51 (0.20)
	5	0.69 (0.27)	0.69 (0.27)	0.58 (0.23)
	4	0.74 (0.29)	0.84 (0.33)	0.69 (0.27)
	3	0.79 (0.31)	0.79 (0.31)	0.63 (0.25)
	2	0.79 (0.31)	0.74 (0.29)	0.81 (0.32)
	1	0.76 (0.30)	0.74 (0.29)	0.71 (0.28)
	0	0.84 (0.33)	0.94 (0.37)	0.79 (0.31)
	1	0.74 (0.29)	0.94 (0.37)	0.69 (0.27)
	2	0.69 (0.27)	0.86 (0.34)	0.71 (0.28)
	3	0.66 (0.26)	0.74 (0.29)	0.56 (0.22)
	4	0.66 (0.26)	0.76 (0.30)	0.53 (0.21)
	5	0.63 (0.25)	0.79 (0.31)	0.71 (0.28)
	6	0.53 (0.21)	0.69 (0.27)	0.53 (0.21)
	7	0.48 (0.19)	0.66 (0.26)	0.43 (0.17)
	8	0.48 (0.19)	0.56 (0.22)	0.28 (0.11)
	9	0.20 (0.08)	0.30 (0.12)	0.10 (0.04)
	10	0.13 (0.05)	0.23 (0.09)	0
	11	0	0.23 (0.09)	0
Right	12	0	0	0

If amperage and film source distance are held constant, the effect of increased exposure time is to lower the voltage in order to maintain film density within a readable limit. The effect of amperage is similar to exposure time, namely, to increase the total flux to the film. The film source distance also affects the total flux density, but the practical matter of adequate specimen coverage with the cone of radiation and other considerations limit use of the film source distance as a variable parameter. Therefore, the film source distance and amperage were held essentially constant during these studies. Voltage and exposure time were the major independent variables.

We know that film resolution increases with density, provided the limits of the eye and the intensity level of the viewing screen are not exceeded. Density became the chief dependent variable for initial film evaluation. The relationship of density variations to film exposure parameters is shown in Figure 7. Density is proportional to voltage and exposure time. We also know that the lowest voltage possible should be used because an increase in voltage increases the percentage of radiation having shorter wavelengths. Short wavelength radiation is more penetrating than long wavelength radiation and results in less contrast in the image of the object being radiographed. Additionally, radiographic film is more sensitive to long wavelengths; thus, the long wavelengths improve image contrast.

Exposure data revealed that the 0.7 mm focal spot was better than any other available size. The X-ray equipment specifications establish the maximum amperage for this focal spot size at 8 to 10 mA. A film source distance of 0.915 m (36 in.) was previously established as the minimum that would give adequate coverage of the test panels. Thus, voltage and exposure time are the only remaining parameters to be varied. Numerous radiographs of weldments obtained by utilizing different combinations of these parameters were made. However, it was necessary to limit the maximum length of exposure time to 2 min. This was based on an estimation of the maximum inspection time that would be acceptable to production personnel.

It was postulated that optimum radiographic parameters are those that produce the greatest defect indications. For example, a crack gets tighter toward the ends and becomes more difficult to detect radiographically or by any other method. Thus, any technique showing maximum length is obviously better than others. Therefore, the apparent length of each defect indication on every film obtained by utilizing various radiographic parameters was carefully measured with the aid of a 7X microscope. The total defect length determined

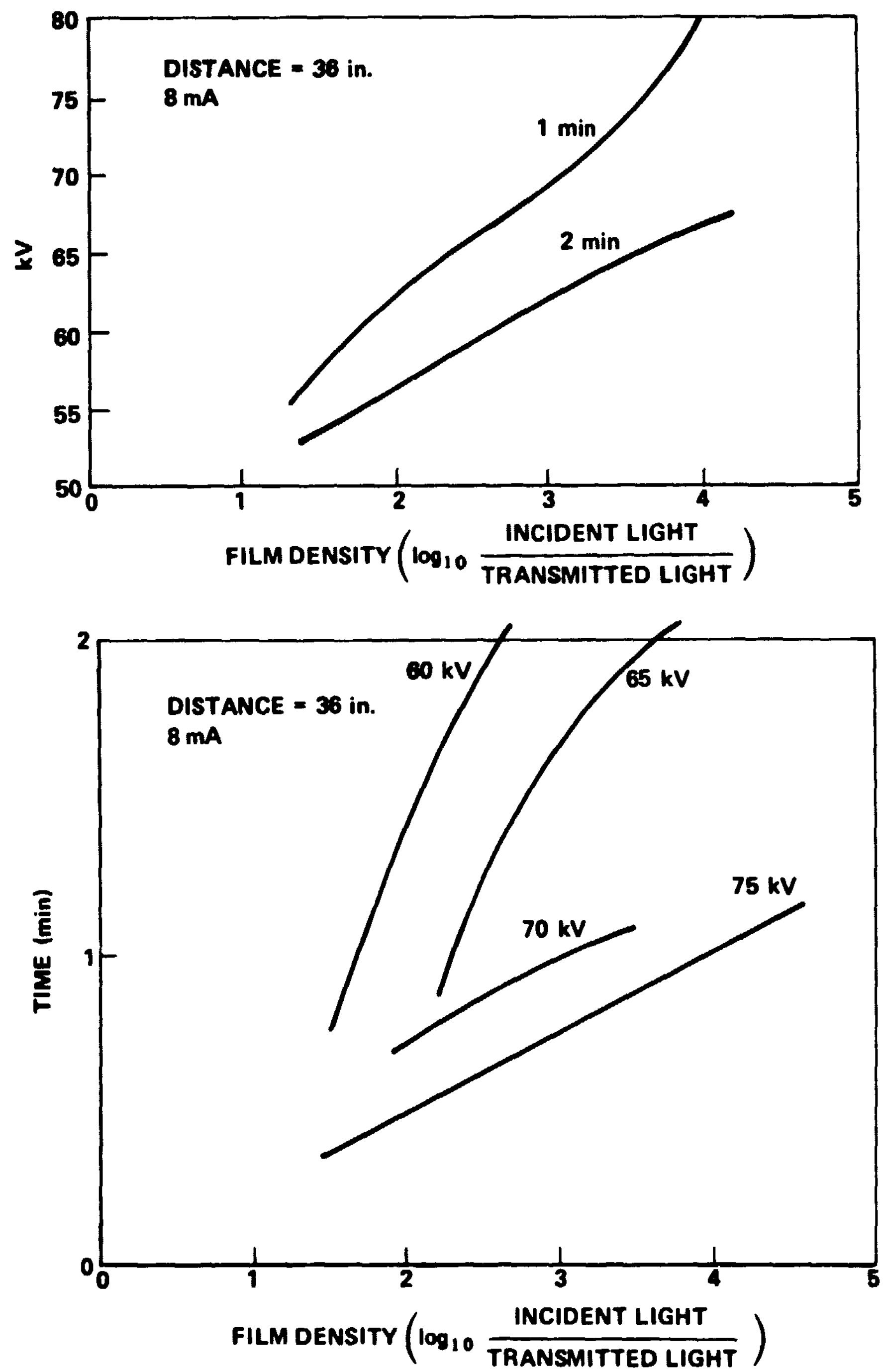

Figure 7. Relationship of density variation to film exposure parameters.

for each exposure condition was then plotted versus the corresponding film density. Curves of this type for a 0.318 cm (0.125 in.) thick aluminum weld are shown in Figure 8. For each exposure time the apparent defect length reaches a maximum as a function of voltage and then recedes as the voltage goes still higher. The combination of parameters yielding the maximum defect length is the optimum technique for this particular material thickness. Similar curves for other thickness values are shown in Figures 9 and 10. It is of interest to note that increases in apparent crack length as exposure time is increased from 1 to 2 min become progressively greater as material thickness increases. It should also be remembered that optimum film exposure parameters will vary to some extent among different X-ray machines.

CONCLUSIONS

Ultrasonic shear waves used in the pulse echo mode provide an acceptable way of measuring the length of weld defects nondestructively, but a pitch and catch shadow technique is required to make accurate crack depth measurements. Weld bead conditions aft t the accuracy of both techniques. Ideally, from an inspector's point of view, weld beads should be shaved, but reliable measurements can be made if the bead profile is low and uniform. Flaw size data obtained ultrasonically compare favorably with radiographic data and with real flaw sizes determined by destructive measurements. Thus, the manual pulse echo and shadow techniques described are effective for measuring flaw size and are inexpensive for evaluating a limited number of flaws. This was the major objective of this project.

Results obtained by the inspection of a shaved weldment with a 10 MHz pulse echo, back-reflection technique are a good indication of the potential of ultrasonics for the nondestructive evaluation of welds. A C-scan recording will show inclusions and porosity very much like a radiograph, as well as indications from randomly oriented cracks. This and other ultrasonic techniques can be automated. Therefore, a low cost ultrasonic system can be used instead of radiography to inspect aluminum welds even though the beads are not entirely removed. Although ultrasonic instrumentation can be improved, available systems can be used to obtain weld evaluations equal to or better than those made with radiography. The major shortcomings of ultrasonics, as most often applied, are inadequate calibration and interpretation of defect indications. The best way to overcome these problems is to evaluate statistically significant

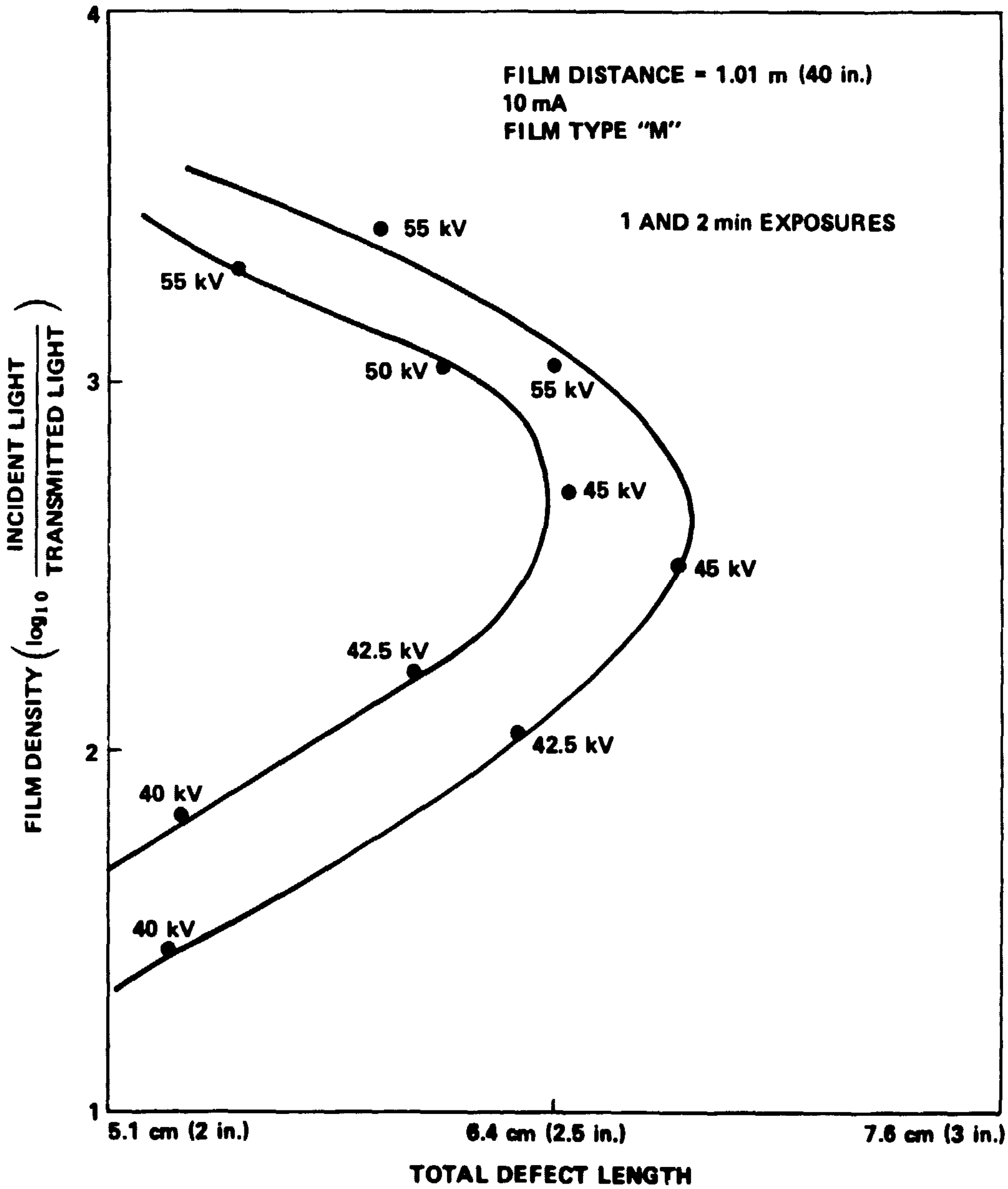

Figure 8. Selection of film exposure parameters for 0.318 cm (0.125 in.) thick aluminum welds.

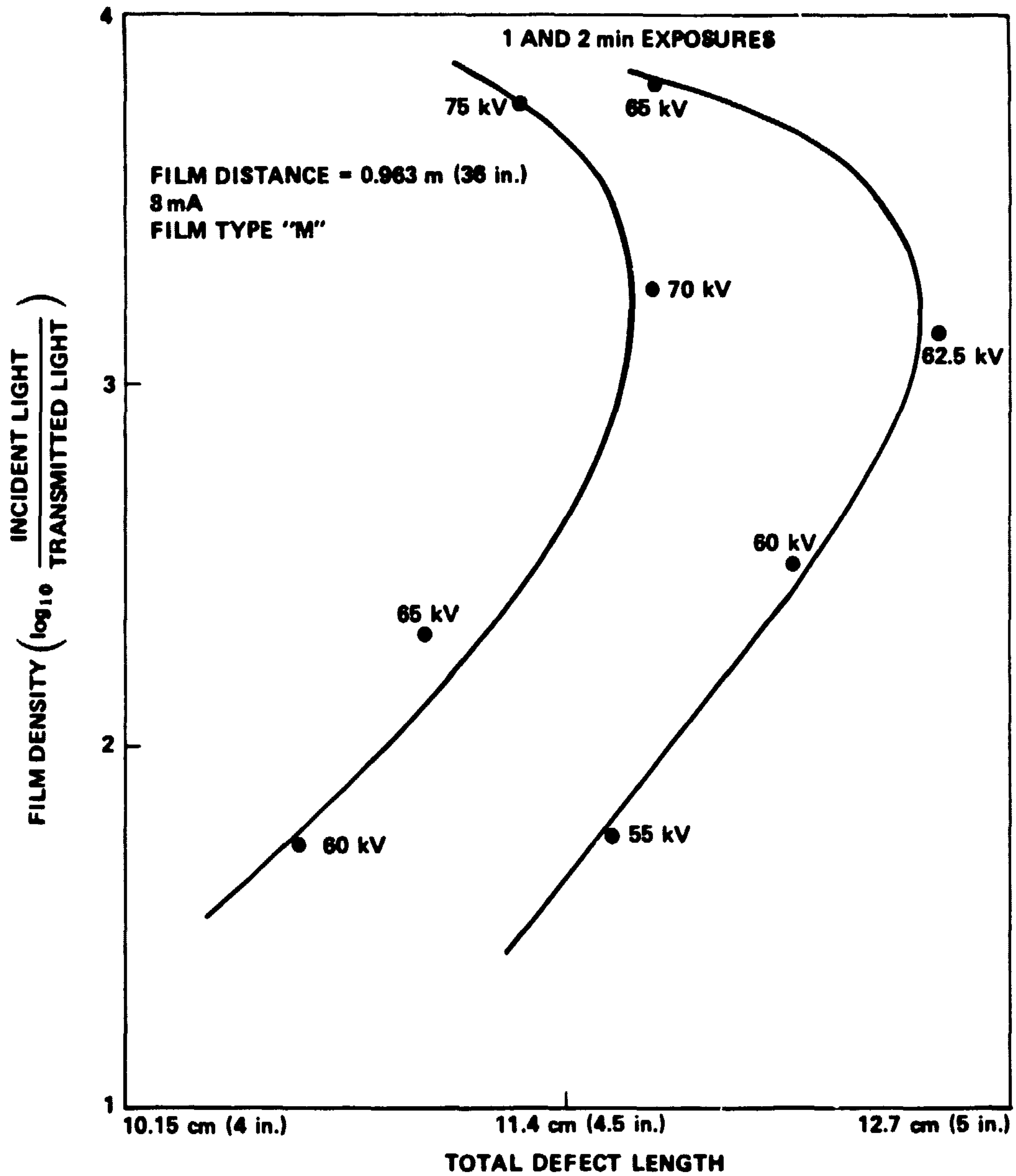

Figure 9. Selection of film exposure parameters for 0.99 cm (0.39 in.) thick aluminum welds.

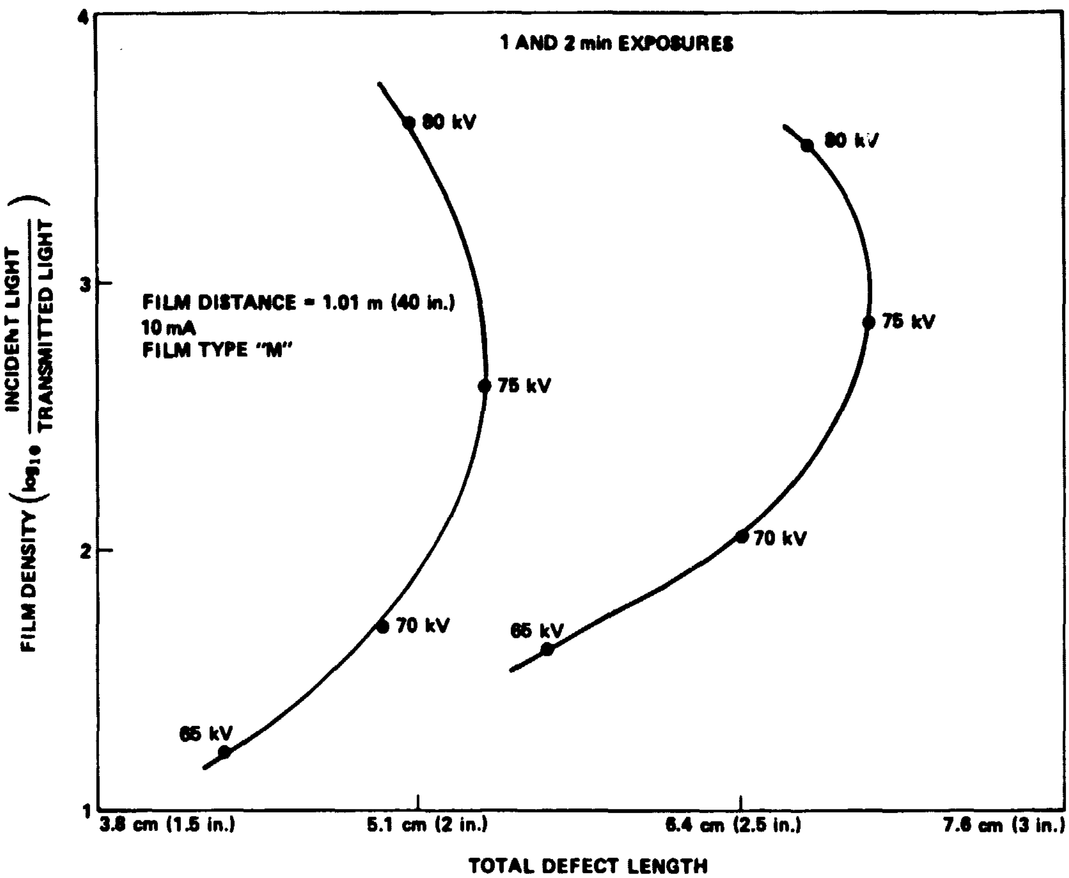

Figure 10. Selection of film exposure parameters for 1.27 cm (0.50 in.) thick aluminum welds.

numbers of weld specimens with well calibrated instrumentation and, subsequently, correlate the indications with the real defect as revealed by destructive measurements. This type of analysis is necessary for effective manual ultrasonic testing as well as for highly sophisticated automated ultrasonic testing.

It has been demonstrated that a careful selection of film exposure parameters for a particular application must be made to obtain optimized flaw detectability. Lower voltage and longer exposure times than those ordinarily used for aluminum welds yield improved results. Radiography and state-of-the-art ultrasonics complement each other, and the combination provides good flaw detection capability.

RECOMMENDATIONS

Four major areas of ultrasonic technology must be improved if its full potential as a quantitative tool for measuring the size of defects in metals is to be realized:

1. Electronic subsystem.

2. Transducer or acoustical subsystem.

3. Calibration procedures for the entire ultrasonic system.

4. Correlation of ultrasonic indications with real defect sizes in materials as obtained by destructive analysis.

Characteristics of available electronic subsystems vary widely. This makes it almost impossible to obtain uniform inspection results from two or more instruments when they are used to evaluate any specimen containing several defects. Furthermore, little would be accomplished by measuring circuit parameters unless provisions are made for adjusting them to meet specified requirements. The variation of transducer characteristics is also significant. Improved quality control of manufacturing procedures, a rigorous initial evaluation of transducer characteristics, and simple, easily applied procedures for periodically checking transducers are necessary to overcome this problem.

Subsequent to the availability of suitable electronics and well characterized transducers, optimized calibration procedures can be developed for each type of inspection problem. Then, one of the most neglected areas of ultrasonic testing can be addressed in a meaningful manner, that is, as illustrated in this report, a systematic correlation of defect indications with real defect sizes as determined by destructive analysis. Statistically significant numbers of specimens containing realistic, naturally occurring defects should be evaluated.

The briefly outlined four point program is highly recommended as the most logical and least costly way of realizing the full potential of ultrasonics as a tool for nondestructive testing. These major areas of ultrasonic technology are being addressed in developmental studies currently being conducted.

APPROVAL

EVALUATION OF ULTRASONICS AND OPTIMIZED RADIOGRAPHY FOR 2219-T87 ALUMINUM WELDMENTS

By W. N. Clotfelter, J. M. Hoop, and P. C. Duren

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

John M. Knadler, III

JOHN KNADLER
Chief, Nondestructive Evaluation Branch

RAYMOND L. GAUSE
Chief, Engineering Physics Division

R. J. SCHWINGHAMER
Director, Materials and Processes Laboratory

☆ U.S. GOVERNMENT PRINTING OFFICE 1976 641-255/244 REGION NO. 4